Radiative transfer modelling for sun glint correction in marine satellite imagery

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature: ....

Abstract

Remote sensing is a powerful tool for studying the marine environment; however, many images are contaminated by sun glint, the specular reflection of light from the water surface. Improved radiative transfer modelling could lead to better methods for estimating and correcting sunglint. This thesis explores the effect of using detailed numerical models of the sea surface when investigating the transfer of light through the atmosphere-ocean system.

New numerical realisations that model both the shape and slope of the sea surface have been created; these contrast with existing radiative transfer models, where the air-water interface has slope but not elevation. Surface realisations including features on a scale from 3 mm to 200 m were created by a Fourier synthesis method, using up to date spectra of the wind-blown sea surface. The surfaces had mean square slopes and elevation variances in line with those of observed seas, for wind speeds up to $15\,\mathrm{m\,s^{-1}}$. Ray-tracing using the new surfaces gave estimates of reflected radiance that were similar to those made using slope statistics methods, but significantly different in 41% of cases tested. The mean difference in the reflected radiance at these points was 19%, median 7%. Elevation-based surfaces give increased sideways scattering and reduced forward scattering of light incident on the sea surface.

The elevation-based models have been applied to estimate pixel-pixel variation in ocean colour imagery and to simulate scenes viewed by three types of sensor. The simulations correctly estimated the size and position of the glint zone. Simulations of two ocean colour images gave a lower peak reflectance than the original values, but higher reflectance at the edge of the glint zone. The use of the simulation to test glint correction methods has been demonstrated, as have global Monte Carlo techniques for investigating sensitivity and uncertainty in sun glint correction.

This work has shown that elevation-based sea surface models can be created and tested using readily-available computer hardware. The new model can be used to simulate glint in a variety of situations, giving a tool for testing glint correction methods. It could also be used for glint correction directly, by predicting the level of sun glint in a given set of conditions.

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